Scientific Paper

Functional composition of the edaphic macrofauna in five pastureland agroecosystems in the Granma province, Cuba

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Abstract

Objective: To characterize the functional composition of the edaphic macrofauna in five pastureland agroecosystems in Granma province, Cuba.

Materials and Methods: The study was conducted in two natural pasturelands: natural pastureland with trees and pastureland of natural grasses, with dispersed trees and association of cultivated grasses and trees. Sampling was performed twice per year, during the rainy and the dry season. The edaphic macrofauna was collected according to the TSBF (Tropical Soil Biology and Fertility) methodology and by pitfall traps. The identified organisms were classified into soil engineers, litter detritivores, herbivores and predators. The proportional abundance of each functional group (%) was calculated and the proportion comparison analysis (chi-squared) was carried out with the statistical package ComparPro, version 1.

Results: Three taxonomic units were identified, classified as soil engineers, seven detritivores, eight herbivores and six predators. There was absolute dominion, regarding proportional abundance, of soil engineers in the five studied agroecosystems and in all the sampling periods. The detritivorous order Isopoda was not present in the deforested natural pastures and continuous grazing. To the functional group called parasitoid, individuals of seven Hymenoptera and Diptera families belonged.

Conclusions: The analysis of the functional groups of the edaphic macrofauna allowed to determine the presence of all the groups in the studied agroecosystems, with predominance of soil engineers. The pasturelands with scarce vegetation and continuous grazing provided neither habitat nor necessary conditions for the development of detritivorous organisms.

Keywords: animal husbandry systems, soil macroinvertebrates, soil engineers, detritivores

Introduction

The edaphic fauna, as fundamental fraction of the terrestrial biodiversity, provides multiple environmental services in benefit of human welfare and health. Organic matter decomposition, nutrient supply for the plants, maintenance of soil structure, water movement and holding throughout the edaphic profile, biological control of pests and diseases, carbon sequestration and release and regulation of the composition of atmospheric gases constitute ecosystemic services (Tanjung *et al*., 2020; Machado-Cuellar *et al*., 2020).

Soil engineers, litter detritivores, herbivores and predators constitute the different functional groups that compose the edaphic macrofauna, and which participate significantly in the regulation of edaphic processes (Cabrera-Dávila and López-Iborra, 2018). The study of the composition and functional activity of the soil macrofauna is important to understand its potential effects on the edaphic medium and plant productivity (Cabrera-Dávila, 2019). In this sense, Clemente-Orta and Álvarez (2019) stated that, in recent years, the ecological studies are increasingly moving towards approaches based on functional traits to understand in more detail the ecosystemic services offered by biodiversity and enhance its positive effects on agroecosystems.

In Cuba, the studies that describe the performance of the macrofauna functional groups with regards to the different land uses have been mostly conducted in the western region of the country (Cabrera-Dávila and López-Iborra, 2018), and there are no references of this type of studies in pasturelands of the eastern region. The objective of this study was to characterize the functional composition of the edaphic macrofauna in five pastureland agroecosystems of the Granma province.

Materials and Methods

Location. The research was conducted in five pastureland agroecosystems, in three municipalities

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of the Granma province, located in the south-west portion of the eastern region of the island of Cuba.

Characteristics of the agroecosystems. Table 1 shows the main characteristics of the agroecosystems of such province. Sampling was carried out twice per year, between July, 2014, and March, 2017. In order to facilitate the statistical analysis and the characterization of the variables object of study three years were defined 1) rainy season (RS)-2014 and dry season (DS)-2015, 2) RS-2015 and DS-2016, 3): RS-2016 and DS-2017. In the rainy season, from July to September were taken as sampling months and in the dry season, from January to March, as they were the most representative of both climate periods. For such purpose the criterion of specialists from the Provincial Meteorology Center in Granma was taken into consideration.

Sampling and identification of the edaphic macrofauna. Two methods were used: the one recommended by the Tropical Soil Biology and Fertility (TSBF) program (Anderson and Ingram, 1993) and pitfall traps (Moreira *et al*., 2012). For the former, the litter was previously cleaned and all types of strange bodies, such as stones and plant residues, were removed. In the diagonal of the sampling area five monoliths per hectare, of 25 x 25 x 20 cm, at distance of 20 m, were extracted. The individuals of the macrofauna were manually collected and counted *in situ*. The earthworms were preserved in 4 % formaldehyde and the other invertebrates, in 70 % ethanol.

For the second sampling method, nine traps were placed in each study area, arranged in the two diagonals in the form of cross, with a trap at the center. Plastic recipients, of 8 cm diameter and 10 cm of depth, were used, which were buried at soil level, with the lowest possible disturbance in the surrounding area. Afterwards, a 0,003 % detergent aqueous solution was added, prepared commercial liquid detergent and they were covered with dried leaves and plant remains proper of each agroecosystem. After seven days, the content of the traps was collected in glass flasks and these were transferred to the laboratory. With the utilization of the stereoscope the individuals from the solution were extracted and counted and were placed in vials with 70 % ethanol.

For the identification of the preserved specimens Brusca and Brusca (2003) was consulted. The entomological collection, belonging to the provincial Plant Health laboratory in Granma, was also examined.

From the functional point of view, the macrofauna was grouped into four fundamental groups: soil engineers, predators, litter detritivores and herbivores (Cabrera-Dávila and López-Iborra, 2018). In addition, the category "parasitoids" was established for the traps.

Statistical analysis. The proportional abundance of each functional group (%) was calculated through the difference of the number of individuals belonging to each group and the total of individuals from all the functional groups. Proportion comparison analysis (chi-squared) was carried out with the statistical package ComparPro, version 1 (Font *et al*., 2007).

Results and Discussion

Three taxonomic units, classified as soil engineers, seven detritivores, eight herbivores, and six predators, were identified. In the group of soil engineers, the prevailing orders in all the agroecosystems were Hymenoptera (Formicidae) and Isoptera. Among the litter detritivores, the found macrofauna orders were: Blattodea, Isopoda and Dermaptera. The orders Orthoptera, Hemiptera, Lepidoptera and Coleoptera (Scarabaeidae) were the most common herbivore individuals. In these agroecosystems, the predators were represented, mainly, by Araneae and Coleoptera, of the families Carabidae and Staphylinidae (table 2).

It is important to indicate two of the differences that were observed in the five agroecosystems in the functional composition of their macrofauna. It is significant that, among the soil engineers, there was no presence of the order Haplotaxida in the natural pasturelands (table 2). This is due to the characteristics of these organisms, because they are totally deforested, which reduces the litter sources deposited on the soil; besides, the continuous grazing method is used, which causes negative incidence of cattle on the soil physical properties.

It is acknowledged that the excessive trampling by the animals causes mechanical destruction of the microhabitat and stability of the organic-mineral aggregates of the soil, which affects its porosity, increases its compaction and, thus, there is lower water infiltration and lower oxygen availability, which limits the activity of the soil biota (Wang *et al*., 2018).

Pereira *et al*. (2017) stated that earthworms tend to prevail in humid, non-compacted, edaphic environments with high organic matter content. Cabrera *et al*. (2011), in a study in the western region of Cuba, which included forests, pasturelands, staple crops and sugarcane plantations, observed that

Table 1. Main characteristics of the studied agroecosystems.

Agroecosistema	El Triángulo and El Progreso	Cupeycito	Ojo de agua	Pasture Station
Classification	Natural pastures	Cultivated grasses + dispersed trees	Natural pastures + trees	Association of cultivated grass + trees
Municipality	Bayamo	Jiguaní	Guisa	Bayamo
Affiliation	UBPC Francisco Suárez Soa	Genetic Enterprise Manuel Fajardo	Rafael Almaguer's farm, CCS Braulio Coroneaux	Agricultural Research Institute Jorge Dimitrov
Purpose	Milk production	Calf rearing	Bull fattening	Bull fattening
Soil type	Pellic Vertisol	Carbonated smooth brown	Carbonated smooth brown	Fluvisol
Grazing method	Continuous	Rotational	Continuous	Rotational
Total grazing area, ha	El Triángulo:18,5 El Progreso: 20,4	14,2	6,7	0,8
Sampling area, ha and percentage it represents of the total area	El Triángulo: 2 11 El Progreso: 2 10	1,8 13	1,2 18	0,8 100
Prevailing pasture type	*Dichantium caricosum* L. A. Camus) and *Cynodon nlemfuensis* Vanderyst.	*Megathyrsus maximus* (Jacqs.) B.K. Simon & S.W.L. Jacobs	*Dichantium caricosum* L. A. Camus	Silvopastoral system of *M. maximus* grass and *Leucaena leucocephala* (Lam.)
Forage area, ha	*Saccharum officinarum* L.: 2 *Cenchrus purpureus* (Schumach.) Morrone:1,5	1,0 4,0	0,5 3,0	-
Exploitation time, years	20	10	7	10
Breed and stocking rate, LAU ha^{-1}	Siboney crossbred 1,5	Creole 1,7	Crossbred 2,2	Siboney crossbred 1
General conditions	Totally deforested grazing area, without paddocks, it is flooded in the rainy season	Good level of shade by trees and paddocks, high amount of stones. Tree species: *Cocos nucifera* L., *Guazuma ulmifolia* Lam and *Populus* sp.	Good level of shade by trees, without paddocks, relief with slope (10 %). Susceptibility to erosion. Tree species: *L. leucocephala*; *Samanea saman* (Jacq.) Merr; *Swietenia mahagoni* (L) Jacq); *Cedrela odorata* L.	Good shade level, zone of intense drought

the behavior of earthworms indicated the level of anthropic intervention, due to the intensity of land use and the degree of disturbance of the edaphic medium.

There was not presence either in the pasturelands of the order Isopoda, belonging to the functional group of litter detritivores. Detritivorous organisms, like the ones belonging to the order Isopoda, are very

Table 2. Functional composition of the edaphic macrofauna in five pastureland agroecosystems.

Functional group	Order/ **Family**/ *Subfamily*	Natural pastureland I (Triángulo)	Natural pastureland II (Progreso)	Cultivated grasses + dispersed trees	Natural pastureland + trees	Association of cultivated grass + trees
Soil engineers	Hymenoptera: **Formicidae**	X	X	X	X	X
	Isoptera	X	X	X	X	X
	Haplotaxida			X	X	X
Litter detritivores	Blatodea			X	X	X
	Dermaptera	X			X	X
	Diplopoda[¥]			X		X
	Archaeogastropoda	X	X	X	X	X
	Isopoda			X	X	X
	Coleoptera: **Nitidulidae**					X
	Coleoptera: **Tenebrionidae**	X		X		X
Herbivores	Orthoptera	X	X		X	X
	Hemiptera	X	X	X	X	X
	Lepidoptera	X	X		X	X
	Thysanoptera	X				X
	Coleoptera: **Chrysomelidae**			X	X	X
	Coleoptera: **Curculionidae**			X		
	Coleoptera: **Elateridae**:			X		X
	Coleoptera: **Scarabaeidae**	X	X	X	X	X
Predators	Araneae	X	X	X	X	X
	Opiliones					X
	Chilopoda*		X	X		X
	Coleoptera: **Staphilinidae:** *Staphylininae*			X		X
	Coleoptera: **Carabidae**	X		X	X	X

[¥]class

sensitive to soil physical and chemical changes, as well as to sudden temperature and humidity changes in their habitats, for which they can be used as indicators of soil quality (Chávez, 2020). Other authors emphasize the importance of Isopoda in litter decomposition and interaction with soil microorganisms (Pey *et al*., 2019).

As has been analyzed, the conditions of these pasturelands are not favorable for the development of these organisms. Meanwhile, for the other systems, when incorporating the tree element soil conditions are improved, because the deposition of litter of better quality and quantity is favored. Hernández-Chavez *et al*. (2020) asserted that the density of edaphic macrofauna is affected by the richness of the plant species present in the systems and the cover. This could be explained because diverse plant species provide the soil biota with propitious habitats for its development, due to the availability of nutrients and temperature and humidity conditions that favor its development.

The order Coleoptera stands out as the most diverse one, regarding functional groups, because the presence of individuals with detritivorous, herbivorous and predator habits was observed. Díaz-Porres *et al*. (2014), in a study conducted to evaluate the relation between macroarthropods and agricultural intensification, which included pasturelands, obtained a similar result. Escobar-Montenegro *et al*. (2017) considered it an indicator of the soil disturbance degree, as it had higher abundance in the latifoliate forest. It was followed by the silvopastoral system and, lastly, the studied traditional paddock system. Coleopterans perform valuable ecological functions for the balance of agroecosystems, because they are fundamental by burying manure and preventing cattle from rejecting the grazing area that has dungs (Hernández-Chavez *et al*., 2020).

Among herbivores, the presence of the family Chrysomelidae is reported, which is considered pest in agricultural crops (Cabrera *et al*., 2011). In this group *Mocis latipes* (Lepidoptera: Erebidae) and *Monecphora bicincta fraterna* (Hemiptera: Cercopidae) were also detected, cataloged as the main pests in the pasturelands of Cuba.

Regarding the number of individuals, the litter detritivores were very little represented. In all the researched agroecosystems, even in the natural pastureland with trees, their presence was not detected by the monolith method (table 3).

According to Cabrera-Dávila (2019), the organisms belonging to this trophic group are the main ones in charge of crushing plant and animal remains; in addition, they reduce the size of detritus particles and increase the surface exposed to the decomposition activity carried out by bacteria and fungi. According to the above-cited author, without the action of these organisms (woodlice, millipedes, snails) the processes of organic matter decomposition and nutrient recycling in the soil.

Rueda-Ramírez and Varela (2016) related the presence of detritivorous taxa (Gastropoda, Diplopoda and Diptera larvae) to characteristics of the plant composition and to its quality. In these authors' research it was more varied in the forest, due to the highest plant richness with regards to the coffee crop. Thus, they stated that this group of litter transformers can become a disturbance indicator, which grants relevance to the functional classification of the edaphic macrofauna.

Noguera-Talavera *et al*. (2017) associated the high presence of detritivores with the high rate of organic matter decomposition. Meanwhile, Pollierer *et al*. (2021) highlighted the strong influence of soil pH on the activity of the detritivorous macrofauna. In general, the organic matter content and the carbon/nitrogen ratio contained in the soil are the conditions that influence the most the diversity and functionality of edaphic macrofauna groups (Díaz-Porres *et al*., 2014).

There was absolute dominion regarding the proportional abundance of soil engineers in the five studied agroecosystems in all the sampling periods (tables 3 and 4), in both sampling methods used (with the exception of the DS of the third sampling year in the natural pastureland I, where there were no individuals). The other functional groups were less represented, generally below 10 %, with the exception of herbivores in Cupeycito, in the rainy season of the first year, where their abundance was 31 %, and of predators in El Progreso, in the dry season of the third year, which exhibited proportional abundance of 20 %, both cases by the method of monoliths.

In the statistical analysis carried out for the macrofauna determined by the method of monoliths, significant interaction was observed only between season and functional groups in the agroecosystem "Ojo de agua" in the first year, and in the second and third year in the "Estación de Pastos",with predominance of soil engineers (table 3). In all the cases significant differences were observed of the soil engineers with regards to the other functional groups, which generally id not differ among them, in all the agroecosystems.

Regarding the functional groups of the edaphic macrofauna determined with the pitfall traps, a similar behavior to the one noted in the above-mentioned treatment was observed, that is, absolute predominance of the proportional abundance of soil engineers with regards to the other functional groups (table 4). The fact that Hymenoptera (Formicidae) and Isoptera are insects with social life habits, influences this group showing the highest proportional abundance.

Soil or ecosystem engineers promote disturbances in the micromorphological and physical attributes of the soil, such as water infiltration and soil aeration due to the increase of porosity, by establishing galleries, channels and pores that favor aeration, drainage, stability of aggregates and water holding capacity (De Almeida *et al*., 2020). In addition, they generate biogenic structures that are

Table 3. Seasonal performance of abundance (%) of the functional groups of the macrofauna, determined by the method of monoliths.

Functional group	Year 1		Year 2		Year 3	
	RS	DS	RS	DS	RS	DS
Natural pastureland I (Triángulo)						
Engineers	94^{a}	100	100	94^{a}	96^{a}	0
Detritivores	0^{b}	0	0	2^{b}	0^{b}	0
Herbivores	3^{b}	0	0	0^{b}	2^{b}	0
Predators	3^{b}	0	0	4^{b}	2^{b}	0
SE ±	7,22	-	-	2,35	5,79	-
P - value	<0,001			<0,001	<0,001	
Natural pastureland II (Progreso)						
Engineers	95^{a}	99	99	99^{a}	92^{a}	6^{b}
Detritivores	3^{b}	0	0	$0{,}5^{b}$	1^{b}	0^{b}
Herbivores	2^{b}	0	0	0	0^{b}	0^{b}
Predators	0	1	1	$0{,}5^{b}$	0^{b}	1^{b}
SE ±	6,24	5,89	5,18	1,87	2,63	
P - value	<0,001	<0,001	<0,001	<0,0001	<0,0001	
Cultivated grasses + dispersed trees						
Engineers	40^{a}	37^{a}	99^{a}	97^{a}	100	$97{,}5^{a}$
Detritivores	2^{c}	$1{,}5^{c}$	$0{,}5^{b}$	$0{,}8^{b}$	0	0
Herbivores	19^{b}	0^{c}	$0{,}5^{b}$	$1{,}3^{b}$	0	2^{b}
Predators	$0{,}5^{c}$	0^{c}	0	$0{,}9^{b}$	0	$0{,}5^{b}$
SE ±	2,42		3,27	2,05	-	2,88
P - value	<0,001		<0,001	<0,001	<0,0001	<0,0001
Cultivated pastureland + trees						
Engineers	78^{a}	$17{,}8^{b}$	100	$99{,}6^{a}$	98,1	91^{a}
Detritivores	0	0	0	0	0	0
Herbivores	$1{,}4^{c}$	2^{c}	0	$0{,}2^{b}$	0	$6{,}7^{b}$
Predators	$0{,}4^{c}$	$0{,}4^{c}$	0	$0{,}2^{b}$	1,9	$2{,}3^{b}$
SE ±	1,68		-	2,1	6,93	5,0
P - value	0,0002			<0,001	<0,001	<0,001
Association of cultivated grass + trees						
Engineers	$93{,}4^{a}$	$92{,}5^{a}$	50^{a}	44^{b}	$17{,}9^{b}$	$81{,}1^{a}$
Detritivores	2,4a	$1{,}2^{b}$	0^{c}	$0{,}8^{c}$	0	0
Herbivores	$1{,}8^{b}$	$1{,}7^{b}$	$0{,}3^{c}$	$3{,}1^{c}$	$0{,}4^{c}$	$0{,}5^{c}$
Predators	$2{,}4^{b}$	$4{,}6^{b}$	$0{,}7^{c}$	$1{,}1^{c}$	$0{,}1^{c}$	$0^{cç}$
SE ±	3,36	3,29	1,22		1,29	
P - value	<0,001	<0,001	<0,0001		0,0266	

DS: dry season; RS: rainy season
a, b and c: different letters between rows differ at $p \leq 0{,}05$, according to Duncan

Table 4. Seasonal performance of abundance (%) of the functional groups of macrofauna, determined by the pitfall trap method.

Functional group	Year 1		Year 2		Year 3	
	RS	DS	RS	DS	RS	DS
Natural pastureland I (Triángulo)						
Engineers	97,7^{a}	78,6^{a}	100	79^{a}	97,6^{a}	94,3^{a}
Detritivores	0	2,4^{b}	0	7,8^{b}	0,8^{b}	2,7^{b}
Herbivores	0,3^{b}	9,5^{b}	0	5,9^{b}	0,8^{b}	1,3^{b}
Predators	1^{b}	7,1^{b}	0	5,9^{b}	0,8^{b}	0,7^{b}
Parasitoids	0	2,4^{b}	0	1,4^{c}	0	1^{b}
SE ±	2,42	6,17	-	1,43	3,87	2,32
P - value	<0,0001	<0,0001		<0,001	<0,001	<0,001
Natural pastureland II (Progreso)						
Engineers	100	95,6^{a}	11,03^{b}	87,2^{a}	76,28^{a}	6,01^{bc}
Detritivores	0	0	0,28^{c}	0,86^{c}	0^{d}	1,8^{cd}
Herbivores	0	0,9^{b}	0,02^{c}	0,12^{c}	9,31^{b}	3,3^{cd}
Predators	0	3,5^{b}	0,23^{c}	0,14^{c}	2,1^{cd}	0,6^{d}
Parasitoids	0	0	0,05^{c}	0,07^{c}	0,3^{d}	0,3^{d}
SE ±	-	4,43	0,46		1,64	
P - value		<0,001	<0,0001		<0,0001	
Cultivated grasses + dispersed trees						
Engineers	90,2^{a}	80,2	23,36^{c}	31,43^{a}	77,7^{a}	94,5^{a}
Detritivores	7,8^{b}	19,8	6,13^{e}	10,25^{d}	9,5^{b}	5^{b}
Herbivores	1,6^{c}	-	0,08^{f}	27,65^{b}	9^{b}	0,6^{c}
Predators	0,4^{c}	-	0,08^{f}	0,42^{f}	1^{c}	0
Parasitoids	-	-	0^{f}	0,59^{f}	2,9^{c}	0
SE ±	1,89	3,18	0,87		1,39	1,45
P - value	<0,001	<0,001	<0,0001		<0,001	<0,001
Natural pastureland + trees						
Engineers	97,8^{a}	9,0^{a}	59,07^{a}	19,26^{b}	63,61^{a}	33,33^{b}
Detritivores	1,5^{b}	0,36^{b}	7,83^{c}	9,48^{c}	0,50^{c}	1,57^{c}
Herbivores	0,7^{b}	0,72^{b}	0,08^{d}	1,58^{d}	0,17^{c}	0,25^{c}
Predators	0	0	0,3^{d}	0,98^{d}	0,17^{c}	0,41^{c}
Parasitoids	0	0	0d	1,43^{d}	0	0
SE ±	1,27	2,85	0,82		0,95	
P - value	<0,0001	<0,001	<0,0001		<0,0001	
Association of cultivated grass + trees						
Engineers	99,6^{a}	100	63,40^{a}	24,09^{b}	68,32^{a}	63,74^{a}
Detritivores	0,18^{b}	0	3,04^{d}	1,76d^{e}	5,50^{c}	21,25^{b}
Herbivores	0,13^{b}	0	0,14^{e}	6,94^{c}	24,48^{b}	15,01^{b}
Predators	0,09^{b}	0	0,20^{e}	0,14^{e}	1,57^{cd}	0
Parasitoids	-	-	0,03^{e}	0,27^{e}	0,13^{d}	0
SE ±	0,84	-	0,55		1,45	2,51
P - value	<0,0001		<0,0001		<0,0001	<0,0001

DS: dry season; RS: rainy season

a, b and c: different letters between rows differ at $p \leq 0,05$ according to Duncan nutrient reservoirs (earthworm feces and termite and ant nests and mounds), control the availability of resources for other organisms and activate the edaphic microflora through mutualistic interactions (Amazonas *et al*., 2018). According to Gongalsky (2021), this functional group concentrates the attention in the studies conducted about the functional groups of the soil macrofauna at present.

Cabrera *et al*. (2011) also noted the predominance of soil engineers in pasturelands of Guinea grass (*M. maximus*) and star grass (*C. nlemfuensis*), in the San José de las Lajas municipality of Mayabeque province, Cuba. Noguera-Talavera *et al*. (2017) found similar results in a system under agroeological conversion of *M. oleifera*; while in the traditional system detritivores prevailed.

In turn, Gutiérrez-Bermúdez *et al*. (2020) equally reported the predominance of the group of soil engineers in animal husbandry and silvopastoral ecosystems in the dry corridor of Nicaragua. The families Formicidae, Termitidae and Lumbricidae belonged to this group, with prevalence of Formicidae in both system types.

Barros *et al*. (2020) found strong correspondence of the detritivorous and predator groups with the land use of seasonal semideciduous forest. Meanwhile, in the corn crop predators and soil engineers prevailed, fundamentally, belonging to Hymenoptera (Formicidae). The authors indicate that in the forest the higher plant diversity provides higher food availability for detritivorous organisms, which allows the trophic chain to become complex, facilitating the presence of predator organisms in these systems.

Similar results were obtained in Cuba, by Cabrera-Dávila and López-Iborra (2018) in two sites of evergreen forest in El Salón, Sierra del Rosario. The functional composition of the edaphic community was similar in both sites, and the most outstanding groups were the litter detritivores, soil engineers and predators. These authors state that this structure barely changes in other land use systems studied in Cuba, such as in secondary forests; but it does in pasturelands and crops with higher disturbance a stress on the soil, where richness and abundance decrease and engineer and herbivorous groups prevail.

In spite of the beneficial effects of soil engineers on its properties, it is necessary to distinguish earthworms and termites from ants. The first two groups have detritivorous feeding habits and participate in litter fragmentation, organic matter decomposition dynamics and nutrient recycling in the ecosystem (Sofo *et al*., 2020), for which they are favored with higher plant cover and soil protection. Thus, they can be used as indicators of good quality of the edaphic medium (Masin *et al*., 2017).

Regarding ants, they are omnivorous and occupy a large variety of niches, for which they can utilize a broad range of resources (Nelson *et al*., 2018). Their generalist habits allow them to compete and survive successfully, displacing other soil organisms with detritivorous function. Thus, they affect the ecosystemic services of organic matter decomposition and nutrient recycling. They are resistant to loss of plant cover, to organic matter-poor and compact soils. They are related to highly anthropized, sunny habitats, of high temperature in the soil, with aggressive tillage practices, application of burns and pesticides (Cabrera-Dávila, 2019). For such reason, in this case, in spite of their beneficial function on the physical soil properties, behaving as engineers, their other characteristics determine that they behave as indicators of disturbance of the edaphic medium.

In the pitfall traps a functional group was established, because there are no references of its inclusion in other studies of this type. They were called parasitoids. They belong to the orders Hymenoptera and Diptera (table 5). According to Vázquez *et al*. (2008), parasitoids are developed within the host insect or on it, which almost always dies.

The larval status of the parasitoid is parasite; while the adult has free life and is very active, for which it is called parasitoid. Parasitoids can provide a very important ecological service in the pastureland agroecosystem, behaving like natural enemies of phytophagous insects (Vázquez *et al*., 2008).

The distribution of parasitoids was variable in each studied agroecosystem. In the natural pastureland I (Triángulo) they were observed only in the dry seasons of every year; while in the natural pastureland II (El Progreso) they appeared in all the periods of the second and third year (table 4). In systems of cultivated grasses + dispersed trees they were recorded in the dry season of the second year and in the rainy of the third one. In the association of cultivated grasses + trees they were found in the same periods as in the previous one; they were also recorded in the rainy season of the second year. Lastly, in the natural pastureland + trees, they were observed only in the rainy season of the second year. This was the only period in which presence of parasitoids was observed in all the agroeosystems. In general, their relative abundance was below 3 %.

Table 5. Taxonomic identification of parasitoids.

Order	Family	Genus
Hymenoptera	Aphelinidae	*Aphytis*
		Aspidiotiphagus
		Marietta
	Encyrtidae	*Microterys*
		Cheiloneurus
	Eupelmidae	*Eupelmus*
	Diapriidae	*Trichopria*
	Agaonidae	*Idarnes*
	Eulophidae	*Horismenus*
Diptera	Tachinidae	-

- not determined

It would be interesting to study further this aspect and elucidate the causes of the presence of this particular group of insects in these agroecosystems, which could be related to their feeding sources and the closeness of other crops such as sugarcane, forest and fruit species, among others. The adults of this group require completing their feeding diet with plant nectar, flower pollen or, indirectly, with honey secreted by other insects (Gallegos-Robles, 2016). It is also possible that they find refuge and protection in the grass, legume and weed species present in the pastureland agroecosystems. In addition, the climate conditions of temperature, rainfall, humidity, wind and light (Naranjo and Sáenz, 2011) could have propitiated a favorable habit for these organisms.

Conclusions

The analysis of the functional groups of the edaphic macrofauna allowed to determine the presence of all groups in the studied agroecosystems, with predominance of soil engineers.

The pasturelands with scarce vegetation and continuous grazing provided neither habitat nor necessary conditions for the development of detritivores.

The presence of the functional category parasitoid indicated that in these agroecosystems there are the propitious conditions for its development.

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Conflict of interests

The authors declare that there are no conflicts of interests among them.

Authors’ contribution

- Licet Chávez-Suárez. Designed the research, led the field work, carried out the analysis and interpretation of the results and wrote the paper.
- Idalmis Rodríguez-García. Participated in the research design, in the analysis and interpretation of the results and in the paper writing.
- Wilfredo Estrada-Prado. Participated in the research design and in the field work. Collaborated in writing the paper.
- Magaly Herrera-Villafranca. Collaborated in the research design, carried out the statistical analysis of the results and collaborated in their analysis and interpretation.
- Yolaine Medina-Mesa. Carried out the statistical analysis of the results and collaborated in their analysis and interpretation.

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